



Computational Structural Mechanics

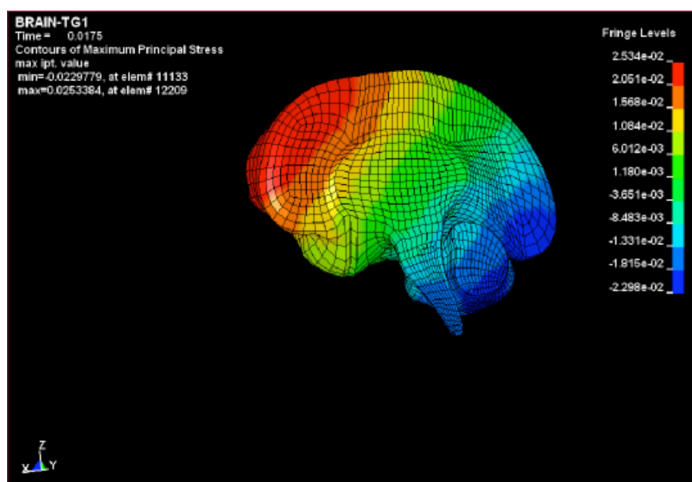
Computations performed on TRACC's high-performance computers (HPCs) will greatly reduce the time for transient dynamic bridge analysis, crash analysis (auto, train, aircraft), and human injury assessment.

Background

Computational structural mechanics is a well-established methodology for the design and analysis of many components and structures found in the transportation field. Modern computer simulation tools, such as the finite-element and meshfree methods, play a major role in these evaluations, and sophisticated commercial software codes (LS-DYNA®, LS-OPT® and Abaqus®) are available for structural analysts. These models are used to assess crashworthiness assessments of vehicles (autos, buses, trucks, trains, and aircraft) under accident conditions. Occupant models are also often included to determine occupant response and to evaluate occupant risk and the potential for developing injury reduction mechanisms.



Bridges are a critical component of the nation's travel infrastructure. The TFHRC is conducting simulations at TRACC to evaluate bridge safety and reliability under extreme and complex loading conditions (image courtesy of Dr. Shuang Jin of the Federal Highway Administration NDE Center).



Motor vehicle crashes are the major cause of traumatic brain injury in the United States. Numerical modeling by the NHTSA at TRACC provides valuable insight into brain response during crashes (image courtesy of Dr. Erik Takhounts of the NHTSA)

Other uses of computational structural mechanics in the transportation field include the design and analysis of important components of the highway infrastructure, such as bridges and roadside hardware. In these multiphysics applications, models are being developed to determine the response of bridge structures to traffic loadings; wind loadings, which may result in so-called flow-induced vibration; and hydraulic loading, which may develop during severe weather flooding of bridges. Recently, numerical studies were started to assess the structural stability of bridges with piers and abutments in scour holes. Also, attention has turned to assessing the structural safety of the nation's aging steel bridges.

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The level of modeling detail in these applications is being increased substantially to provide greater confidence in the computed results. The use of high-fidelity computational models with hundreds of thousands of elements requires the use of massively parallel computers like those at the U.S. Department of Transportation's (USDOT's) Transportation Research and Analysis Computing Center (TRACC), operated by Argonne National Laboratory, and appropriate software, such as LS-DYNA, LS-OPT and Abaqus, that can take advantage of this parallel computing environment.

TRACC's Software

TRACC has a 280-CPU (core) license with Livermore Software and Technology Corporation for use of the LS-DYNA suite of codes and a 21-token license with Simulia for use of Abaqus. Both codes are continuously being upgraded and contain many features that can handle the complexities embedded in USDOT's structural and media-structure interaction problems. Between the two codes the following features are available: explicit- and implicit-time integration; a robust Eigen problem solver; finite-element, extended finite-element, multi-material arbitrary Lagrangian Eulerian, and meshfree methodologies; design optimization and probabilistic analysis

For Users

Scripts for ease of use have been developed by TRACC's expert staff and are posted on the TRACC external wiki (<https://wiki.anl.gov/tracc/TRACC>) along with commands for checking job status. The latest information on using the code can be found on the wiki.

Desktop virtualization is available to users, enabling them to interact with the cluster from a remote location. The NoMachine NX server is installed on the cluster and the NoMachine NX client is available at no cost to the user, providing an efficient and easy way to view finite-element models, develop and modify input files, and display computational results.

TRACC's expert staff is available for consultations on computational mechanics issues and development of collaborative projects. Staff are also available to assist with software- and HPC-related issues.

Current Projects

In one project, the Federal Highway Administration's Turner Fairbank Highway Research Center (TFHRC) has used TRACC's cluster to investigate the chaotic motion of the Bill Emerson Memorial Bridge subjected to traffic loads. The finite-element model consists of more than 1 million elements. Ten days of computing time using 256 CPUs (cores) were required to simulate 100 seconds of traffic flow. In another project that is part of USDOT's Steel Bridge Test Program, TFHRC is assessing the structural integrity of selected steel bridges.

The Human Injury Research Division of the National Highway Traffic Safety Administration (NHTSA) is working on traumatic brain injuries resulting from crashes. The TRACC cluster allows in-depth investigations that can differentiate injuries between various regions of the brain for many accident scenarios. In another project, NHTSA is using modeling and simulation to determine the effect of vehicle and restraint parameters on the kinematics of a crash dummy during a rollover crash simulation.

The Texas Transportation Institute is analyzing and designing roadside safety features. Michigan Technological University is doing microstructure-based modeling to characterize asphalt materials and the Louisiana Transportation Research Center is simulating the performance of pavement structures for rutting performance of chemically stabilized base/subbase materials.

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